

## ABSTRACT

## GRAY SCALE ALL-GLASS PHOTOMASKS

A narrowly defined range of zinc silicate glass compositions is found to produce High Energy Beam Sensitive-glass (HEBS-glass) that possesses the essential properties of a true gray level mask which is necessary for the fabrication of general three dimensional microstructures with one optical exposure in a conventional photolithographic process. The essential properties are (1) A mask pattern or image is grainless even when observed under optical microscope at 1000x or at higher magnifications. (2) The HEBS-glass is insensitive and/or inert to photons in the spectral ranges employed in photolithographic processes, and is also insensitive and/or inert to visible spectral range of light so that a HEBS-glass mask blank and a HEBS-glass mask are permanently stable under room lighting conditions. (3) The HEBS-glass is sufficiently sensitive to electron beam exposure, so that the cost of making a mask using an e-beam writer is affordable for at least certain applications. (4) The e-beam induced optical density is a unique function of, and is a very reproducible function of electron dosages for one or more combinations of the parameters of an e-beam writer. The parameters of e-beam writers include beam acceleration voltage, beam current, beam spot size, addressing grid size and number of retraces.

A method of fabricating three-dimensional microstructures using HEBS-glass gray scale photomask for three dimensional profiling of photoresist and reproducing the photoresist replica in the substrate with the existing microfabrication methods normally used for the production of microelectronics is described.